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GEOLOGICAL SURVEY OF ALABAMA
WALTER BRYAN JONES, STATE GEOLOGIST

BULLETIN 41

OCHERS OF ALABAMA

BY
JELKS BARKSDALE
STAFF GEOLOGIST

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JULY, 1930

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LETTER OF TRANSMITTAL

To His Excellency,
BIBB GRAVES,
Governor of Alabama,
Montgomery, Alabama.

SIR: I have the honor to transmit herewith the manuscript of a report on "Ochers of Alabama", by Jelks Barksdale, with the request that it be printed as Bulletin 41 of the Geological Survey of Alabama.

Very respectfully,

WALTER B. JONES,
State Geologist and Director.

UNIVERSITY OF ALABAMA,
August, 1930.

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INTRODUCTION

Ocher is one of the most widely distributed and easily accessible coloring materials and for these reasons it has been used since ancient times for personal adornment as well as for economic purposes. The American Indians used this mineral extensively in painting themselves for war and tribal ceremonies. The original Indian red pigment was a natural argilaceous ocher from the Island of Ormuz in the Persian Gulf. However, at the present time this pigment is prepared artificially on a commercial scale.

Two other natural pigments, umber and sienna, so named from localities in Italy where they were first mined are varieties of ocher which contain oxides of manganese in addition to the oxides of iron. The manganese oxide imparts a brownish color to the pigment, the intensity of which depends primarily upon the amount of this oxide present. Umber is usually dark brown, while sienna is of a lighter brown, reddish brown or orange color. There is a gradual transition in color from ocher through sienna to umber, and although the characteristic materials are easily recognized, those near the dividing lines are classified with difficulty. Sienna grades into ocher with decreasing iron oxide content, while on the other hand it grades into umber with increasing manganese oxide content. Very little sienna and umber are known to occur in the United States, and most of these pigments as well as the higher grades of ocher used in this country are imported.

Siliceous iron ores, both hematite and limonite, when ground yield very satisfactory natural pigments for the manufacture of protective paints. Practically all the limonite and the "soft" or weathered hematite occurring in Alabama, with the exception of the excessively siliceous grades, are suitable for paint pigments, although the "hard" or unweathered hematite as mined for blast furnace consumption ordinarily contains too much calcium carbonate to be used for this purpose.

In recent years there has been a small production of red hematite for paint pigments from Etowah County.

The chief interest in the ochers of Alabama has usually been shown by people of limited capital, who desire to develop certain deposits and produce the ocher on a rather small scale. A number of the deposits in the State seem to be workable on this basis, and it is particularly to the possible small scale producers that this report is intended to furnish information.

PROPERTIES

Ocher may be defined as the clayey and unconsolidated forms of the minerals limonite and hematite, always with more or less impurities consisting primarily of other metallic oxides, clay and silica. Hematite produces the red ochers, while limonite yields the yellow, orange and brown varieties. The impurities, particularly manganese oxide, exert a certain influence upon the shade of the material, but as a general rule the color depends upon the amount and state of oxidation and hydration of the iron content. The mineral limonite is a hydrous oxide of iron with the chemical formula $2Fe_20_3$. $3H_20$, while hematite is an anhydrous oxide which corresponds to the chemical formula Fe_20_3. When pure these minerals contain 59.8 and 70.0 per cent of iron respectively. The best varieties of yellow ocher range in shade from lemon yellow to golden yellow, and among the reds those with a purplish cast are more valuable.

Since the colors depend for one thing upon the state of hydration of the ferric oxide, the original colors may be changed by driving off all or a part of the combined water—a process known as calcining.

In the solid form ochers have a clayey appearance and a waxy luster. The specific gravity varies according to the percentage of ferric oxide present, but ranges from about 2.5 to 3.5. The particles of the pulverized material are finely divided and appear flocculent and uniform under the microscope. The ground material readily mixes with linseed oil to form a thick paste which can be thinned with the same oil to any desired fluidity. After the oil saturation point, which varies with the different ochers, is reached, each paste will be thinned to the same extent by the addition of equal amounts of oil. The amount of oil required to saturate the pigment varies directly as the combined surface area of the individual particles of the mass, and thus gives an indication of the average particle size of the material.[1]

The chemical constituents of ochers are oxides of iron, silica and alumina, combined water and frequently smaller amounts of manganese oxides, potassium oxide, magnesium oxide and titanium oxide. The content of iron oxide varies from approximately five per cent to eighty per cent. Below five per cent ferric oxide the ocher passes into clay, while at the other extreme it grades into iron ores.

The ocher pigments are "permanent," that is, the colors remain unaltered, even upon exposure to the atmosphere, for an indefinite period of time. The colors are all due to stable chemical compounds so that ochers may be mixed with other pigments without injury to either.

---

[1] Gardner, H. A., and Levy, S. A., *Pigment and Color Index,* Circular No. 352, American Paint and Varnish Manufacturers Association, 1929, p. 529.

GEOLOGY

General.—The ocher deposits of Alabama may be classed according to origin into two distinct groups—sedimentary and residual. The sedimentary deposits are found in the Coastal Plain area of Cretaceous and Tertiary strata in the southern part of the State. These ore bodies occur as lenses or beds of limited areal extent in the unconsolidated strata and are of the same or later geological age as the enclosing formations. The associated materials are ordinarily sands and clays, although gravel and ferruginous sandstone and conglomerate are occasionally encountered.

The residual ochers occur in the area of Paleozoic and crystalline rocks in the northern and eastern parts of the State. These deposits are of secondary origin and are of a much later geologic age than the associated formations. As a general rule these ochers are found on but not in limestone formations and are usually associated with sands and clays, and less frequently with limonite, hematite and ores of manganese.

The contact between the Cretaceous formations to the south and the Paleozoic and crystalline formations to the north may be taken as the dividing line between the two classes of deposits. Thus it is evident that occurrences of this mineral are known in each of the major geologic provinces of the State so that a presentation of the geology of the ochers would practically mean a discussion of the geology of Alabama. Such a treatment does not seem necessary or advisable in this report and for a detailed account of the geology of the State, the reader is referred to *Geology of Alabama,* issued by the Geological Survey of Alabama in 1926 as Special Report No. 14.

Origin.—The lenticular character of the beds of sedimentary ocher indicates that they were deposited in local bogs or depressions similar to those in which the lignite accumulated. This assumption is further strengthened by the fact that at Baker Hill, Barbour County, lignite is found in the same immediate vicinity as the ocher and at approximately the same stratigraphic horizon.

The surface waters flowing into these low-lying areas carried fine-grained sediments in suspension which slowly settled out to form the clay base of the ocher. These surface waters, and particularly the shallow ground waters, brought iron, dissolved as ferrous salts, into the areas. The ferrous compounds of iron dissolved in the waters were oxidized upon exposure to the air, to the ferric state and precipitated as hydrated ferric oxide, which permeated the extremely fine-grained clay base.

The iron was derived from ferruginous minerals, probably pyrite and siderite, contained in the rock masses from which the sediments were derived. Pyrite was oxidized to soluble ferrous sulphate by the action of waters carrying dissolved oxygen, while the ferrous carbonate was readily dissolved by waters containing carbon dioxide or organic acids in solution. The carbon dioxide was derived from the oxidation of plant and animal remains, from the decay of carbonaceous rocks, and from the life processes of animals. The organic acids were produced by the decay of plant remains in marshy or swampy places. Rain water also dissolved carbon dioxide from the atmosphere.

This condition of deposition would obviously result in an intimate and heterogeneous mixture of iron oxide and clay as is actually the case in the ochers. The silica associated with the ocher was apparently brought in with the clay, however, it is possible that the silica was precipitated from solution.

The beds are generally overlain by strata of sand indicating a transition from the swampy or boggy condition. Immediately above the ocher is usually found a consolidated ledge of ferruginous sandstone or conglomerate from a very few inches to one foot in thickness, which indicates the presence of appreciable amounts of iron in the ground waters subsequent to the deposition of the ore bodies. These beds of ocher are dense and impervious, so that the descending ground waters impregnated with soluble salts of ferrous iron were arrested in their downward course and deflected along the dip of the beds with the result that the iron was oxidized and precipitated in the pore space between the sand grains. This hydrated ferric oxide acted as a cement in forming the consolidated ledges of ferruginous sandstone and conglomerate.

The residual ochers are usually closely associated with limestone formations and appear to have resulted from the weathering of impure limestones and the concentration of their residues. The calcium carbonate is relatively soluble and was thus dissolved and carried away by waters containing carbon dioxide or organic acids. The iron and silica are less soluble and, if dissolved at all, they were not carried far before they were precipitated. The clays being relatively insoluble were not removed except by physical force. In certain suitable areas as in synclines and sink holes, the clay accumulated, and the iron carried in solution in the ferrous state was oxidized and precipitated in the gelatinous clay, becoming intimately mixed with it to produce ocher.

OCCURRENCE

A large proportion of the ocher produced in the United States comes from Georgia and Pennsylvania, although in recent years there has been a small output from Alabama, California, Iowa, Vermont and Virginia.[1] Georgia is by far the leading producing state, and a comparatively small area near Cartersville in Bartow County supplies the entire output. This district is unique in that the ocher occurs as irregular veins in the Weisner quartzite of Cambrian age and has been formed by chemical replacement of the silica along fractures in the quartzite by hydrous oxide or iron in solution—a process known as metasomatism.[2]

Extensive deposits of this mineral also occur in France, Germany and England, while important deposits of high grade sienna are found in Italy.

Ocher of more or less purity is widely distributed throughout Alabama, and occurrences of this mineral are known in practically every section of the State. The more important deposits are located near Jackson, Walker Springs and Choctaw Bluff in Clarke County; near Perdue Hill and Jones Mill in Monroe County; near Baker Hill in Barbour County; near Vine Hill and Prattville in Autauga County; near Coosada in Elmore County; about three miles south of Duncanville in Tuscaloosa County; at Shelby in Shelby County; near Pearces Mill in Marion County; and near Allsboro in Colbert County. Lenses of ocher are frequently encountered in the brown iron ore workings near Woodstock in Tuscaloosa County, and outcrops have been reported in the old limonite pits in Talladega County. Other occurrences have been reported near Pell City in St. Clair County; near Fort Payne in DeKalb County; near Guntersville in Marshall County; and along the Gulf, Mobile and Northern Railroad about twenty-two miles northwest of Mobile in Mobile County.

The accompanying map of Alabama (Plate I) shows the location of each of the previously mentioned localities.

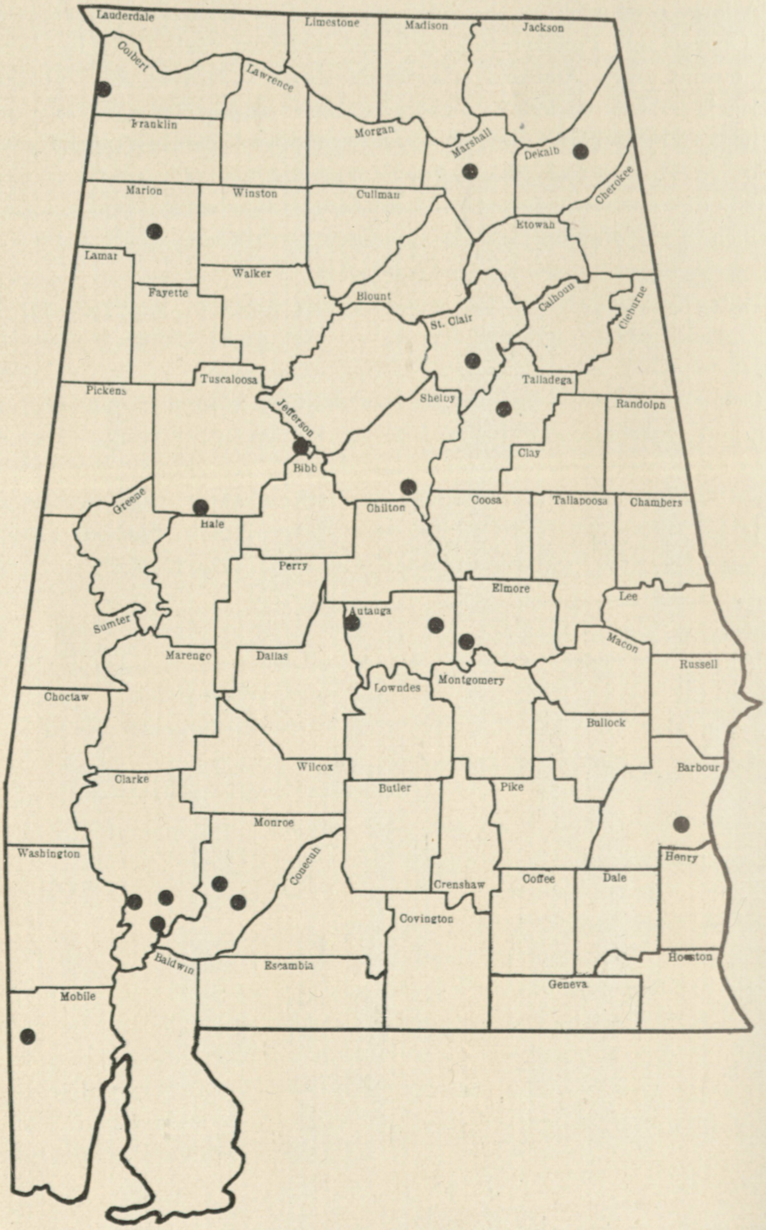
The more important of these beds range from two to six feet in thickness, and in most cases the overburden is not excessive for strip pit mining. Rail or river transportation is readily accessible to the greater part of the deposits, and since a system of improved highways now extends into practically every section of the State, the formerly inaccessible deposits may now be reached by motor trucks. It is fortunate that the most important of these deposits are comparatively close to railroads or navigable rivers.

---

[1] Santmyers, R. M., *Ocher and Ochery Barths,* Circular 3162, U. S. Bureau of Mines, 1929, p. 8.

[2] Watson, T. L., *The Ocher Deposits of Georgia,* Bulletin No. 13, Geological Survey of Georgia, 1906, p. 57.

PLATE I


Lauderdale
Colbert
Lawrence
Limestone
Madison
Jackson
Franklin
Morgan
Marshall
Dekalb
Cherokee
Marion
Winston
Cullman
Etowah
Lamar
Walker
Fayette
Blount
Calhoun
Cleburne
St. Clair
Talladega
Pickens
Tuscaloosa
Shelby
Randolpn
Jefferson
Clay
Bibb
Greene
Chilton
Coosa
Tallapoosa
Chambers
Hale
Perry
Elmore
Lee
Autauga
Sumter
Macon
Marengo
Dallas
Russell
Montgomery
Lowndes
Choctaw
Bullock
Wilcox
Clarke
Barbour
Butler
Pike
Monroe
Conecuh
Washington
Henry
Crenshaw
Coffee
Dale
Covington
Houston
Baldwin
Escambia
Geneva
Mobile

OUTLINE MAP OF ALABAMA SHOWING LOCATION OF OCHER DEPOSITS

GRADES AND SPECIFICATIONS

As a general rule the commercial value of an ocher cannot be determined from its chemical analysis alone, but depends more upon how the various constituents are combined in the ocher, the brightness and uniformity of its color, the average particle size, the oil absorption property and the spreading and covering power.[1] Ochers containing as much as eighty per cent ferric oxide may be less valuable than others containing as low as seventeen per cent of this oxide, which is considered the minimum allowable for paint pigments. Obviously ochers for such uses as in the manufacture of oil cloth and linoleum may be of relatively low grade, with poor color and covering power since they serve primarily as fillers. Thus the most important considerations in this case are low oil absorption and low cost, although in some cases the oil absorption seems to be of secondary importance.

Color.—A high grade ocher for pigment must have a clear, bright and uniform color of a desirable shade, which must also be permanent when exposed to the action of the atmosphere. The adulteration of ochers is of rare occurrence since they are among the cheapest of pigments, although those with poor color may sometimes be intensified by the addition of a small amount of chrome yellow. More desirable shades may also be produced by mixing two or more varieties of ocher. It has already been shown that the colors may be intensified or even completely changed by calcining.

Oil Absorption.—The amount of linseed oil required to produce a paste of uniform consistency varies with the different ochers. This property is important for all uses in which the pigment is mixed with this oil, the most important of which are in the manufacture of paints, linoleum and oilcloth.

Since linseed oil is more expensive per unit of volume than ochers, it follows that a product of a certain consistency can be made cheaper from ochers with low oil absorption than from those with high oil absorption. The oil taken up by the pigment before it is saturated has no value as far as volume and covering power are concerned.

The amount of oil required for saturating ochers is directly proportional to the specific surface of the mass existing at the point of saturation. Since the specific surface of the mass depends upon the degree of sub-division of the composite particles, it measures to a great extent the fineness or average particle size of the pigment.[2]

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[1] Ladoo, Raymond B., *Non-Metallic Minerals,* 1925, p. 385.

[2] Gardner, Henry A., and Levy, Stanley A., *Pigment and Color Index,* American Paint and Varnish Manufacturers Association, 1929, p. 531.

The practical value of knowing the oil absorption factor lies in the information it gives concerning the following physical conditions of the pigments:

1. Relative surface area exposed by the pigment mass.
2. State of sub-division of the pigment particles.
3. Comparative specific surface of various pigments.
4. Variations in fineness or particle sub-division of various lots of the same pigment.

Particle Size.—To be satisfactory for the market, prepared ochers should be very finely pulverized and free from grit, although the presence of finely divided silica is not always objectionable except that it lightens the shade of the pigment. For use in the manufacture of oilcloth and linoleum and low grade paints, ochers should at least be ground to pass a 250-mesh screen since they are not usually ground after mixing with the oil. Although a 250-mesh product is usually acceptable, the finer the better. Extreme initial fineness, however, is not so important for ochers to be used in making high grade paints since these pigments are ground for a considerable time in oil in paint-grinding machines so that the particles may be reduced much smaller than the openings of the finest mesh screens made. For this purpose an initial fineness of 200-mesh is generally satisfactory, but for all uses 325-mesh ochers are more desirable.[1]

It is well to remember that the particles of the ocher proper are ordinarily well within the above limits, and the coarser materials are lumps of ocher and impurities.

Specifications.—Ochers are adapted to a variety of uses, and for these different purposes different properties are desired, as for example, pigments for paint manufacture may have different properties from those used in oilcloth and linoleum. The United States government specifications for ocher is given below: The dried material shall be a hydrated oxide of iron permeating a siliceous base and shall be free from added impurities. The iron oxide content shall not fall below seventeen per cent, and the calcium oxide content shall not exceed five per cent. The coarse particles retained on a 325-mesh screen shall not exceed three per cent of the total weight of the ocher. The color, strength and tone shall be equal to a sample mutually agreed upon by buyer and seller.[2]

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[1] Ladoo, Raymond B., *Non-Metallic Minerals*, 1925, p. 385.

[2] *Recommended Specifications for Ocher, Dry and Paste*, Circular 91, U. S. Bureau of Standards, 1920.

METHODS OF MINING

All the ocher produced in Alabama has been mined by the strip pit method in which the overburden is removed, usually by mule-drawn scrapes, and the ocher is dug from the open cut with picks and shovels. The ocher beds are usually associated with unconsolidated materials which can be removed easily and cheaply, but where the cover is excessive underground methods of mining must be resorted to. Obviously a considerable amount of timbering would be necessary to support the unconsolidated overlying strata.

At many of the exposures in the State, a consolidated ledge of ferruginous sandstone or conglomerate immediately overlies the ocher which would aid materially in supporting the overburden if it did not support it entirely.

The underground mines are usually opened by shafts, by drifts or by tunnels from the sides of hills. The arrangement of the mines is very similar to that followed in iron ore mines, but in most cases the ocher is soft enough to allow digging it from the bed with picks so that blasting is unnecessary. The ocher is usually associated with clay and must be mined carefully so as not to take this material since it cannot be removed from the ocher by washing and settling, and thus lowers the grade of the final product.

The openings should be located above the drainage level of the adjacent territory in order to prevent the accumulation of water and the added expense of pumping.

The larger strip pit mines may be equipped with steam shovels and drag line excavators to remove the overburden and dig the ocher from the bed, however, the ore bodies are usually too small and irregular to justify the installation of large scale and expensive machinery.

PREPARATION

Washing.—It has been shown in a preceding section that the run of mine ocher almost invariably contains some impurities which should be removed before marketing. The purification is practically always accomplished by washing the material in running water—a process based upon the principle that the transporting power of a current of water varies as the sixth power of the velocity of the current. In addition to removing the coarse-grained impurities such as sand, gravel and fragments of rocks, washing also yields a better product because of the uniform mixing. The operation has a number of variations, but the essential steps are given below: The freshly mined ocher is dumped into a log washer where it is disintegrated and the larger and harder constituents are expelled at the upper end of the washer. The finer materials, consisting of ocher and the finely divided impurities, are carried over the lower end of the washer with the water and run down long narrow troughs to settling tanks. The log washer is similar to those used for washing brown iron ores, and consists of a long, slightly inclined trough in which are installed either one or two logs set with steel teeth or paddles, which are rotated by power, applied through gears attached to the logs. The teeth are set along the logs in spirals so as to break up the lumps of ocher and carry the hard and coarse materials to the upper end of the washer where they are expelled.

The rotating elements of the original washers were constructed by driving steel spikes in actual wooden logs—hence the name log washers—but at the present time many of the logs are made of steel throughout. Water is sprayed in continuously along the entire length of the logs, and it overflows at the lower end of the washer, carrying the finely divided ocher and some impurities. The water containing the ocher in suspension flows along long, narrow troughs, which are set at a slight fall so as to decrease the velocity of the water. The decrease in velocity also decreases the carrying power of the water so that the coarser and heavier particles settle out along the trough, and only the ocher and very fine particles of impurities, mostly sand and clay, are carried to the settling tanks.

When transferred to the settling tanks, the heavier or larger particles obviously settle out first, and at some plants this sediment is drawn off and discarded, thus removing most of the impurities, but at the same time a considerable amount of ocher is lost. By inserting spigots at different levels in the settling tank, ocher of any desired fineness may be drawn off.

This method of washing is simple; no elaborate or expensive equipment is required; and the washers do not require skilled workmen for their operation.

Drying.—When the ocher has settled to the bottom of the tanks, the water is syphoned off, leaving a thick, pasty mass, which is dried by solar evaporation until it is hard enough to permit handling. It is then shoveled up and carried to drying houses, where the drying is completed by heat from the sun. The drying houses are long, narrow structures containing rows of horizontal shelves on both sides of a central passageway and spaced one above the other at regular intervals to the top of the structure. The sheds are covered to protect the ocher from rains, but the sides are left open to allow free circulation of air in order to facilitate drying.

In some cases the final drying is carried out over coils of steam-heated pipe rather than in open air racks.[1] This method shortens materially the time required to accomplish the drying, but there is some loss due to the ocher next to the pipes taking a reddish tinge because of too much dehydration. Although many mills are equipped for both methods of drying, heat from the sun is generally utilized because of the frequent damage to the ocher as a result of heating over steam coils.

The dried material is prepared for market either by grinding in revolving disk crushers or by pulverizing in impact pulverizers.

Refined Method of Preparing Ochers.—A more refined method of preparing ochers,[2] which is employed to some extent by the larger producers, is described below: The ocher bearing water from the log washer is fed into the center of an inverted cone-shaped classifier in which there is a rising current of water. The upward velocity of the water is so regulated that the coarser particles settle against the current, while the finer grained ocher is carried over the top of the classifier by the water in suspension. The sand is discharged through a spigot at the bottom of the classifier, while the ocher is delivered to a thickener, where a large part of the water is removed.

If the ocher from the classifier is coarser than desired, it may be reduced to the required fineness by passing the thickened pulp through a ball mill operating in closed circuit with a classifier.

In either case, the thickened pulp is sprayed against the outside of large revolving steel drums, heated from the inside with live steam at about eighty pounds pressure. The ocher is scraped off the drum mechanically as soon as it has been thoroughly dried, or otherwise it may be darkened due to loss of combined water. The dried material is then passed through impact pulverizers where it is finally prepared for market.

CALCINING

The colors of the native ochers may be intensified or otherwise changed by heating—a process known as calcining. This procedure is carried out in inclined, cylindrical rotary kilns, fired with gas or powdered coal, and similar to those employed in the manufacture of lime. The raw material is charged at the upper end of the kiln and the calcined product is discharged by gravity at the lower end in a continuous process.

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[1] Watson, T. L., *Ocher Deposits of Georgia,* Bulletin No. 13, Geological Survey of Georgia, 1906, p 72.

[2] Scott, J. J., Jr., *Earth Colors,* The Chi Beta Phi Record, Vol. 5, No. 2, 1930, p. 43.

The yellow ochers are converted to the red and brown varieties and the colors produced are usually richer than those of the original materials. Between 150 and 250 degrees Centigrade, the yellow color gradually darkens to yellowish brown, and at about 300 degrees changes to orange or red. At higher temperatures, the colors assume brownish casts and finally change to gray, greenish gray or black. The length of time of heating, the rate of cooling and the nature of the impurities also affect the final shade of the product, however, all colors produced by calcining are stable.

The quality of the calcined product does not always vary as that of the original material, thus a poor ocher, with little commercial value as a yellow pigment, may yield a satisfactory red product on calcining.

Ochers may be produced artificially by roasting the mineral pyrite, a sulphide of iron, or the artificial ferrous sulphate, green vitrol, together with a suitable base. Pigments similar to ochers can be prepared chemically by precipitating the iron from solution around some fine-grained base.[1] An interesting example of this method is given below: A solution of copperas is added to milk of lime and a precipitate of calcium sulphate and ferrous hydroxide is produced. This precipitate is spread out and the ferrous hydroxide is allowed to oxidize slowly until the proper shade has been reached when it is quickly dried. Iron oxide pigments are also produced as by-products in a number of metallurgical operations, as for example, in the preparation of pure alumina for the manufacture of aluminum.

The larger part of the ocher used in the United States is not calcined, but this operation can be carried out at low cost, and where the value of the pigment can be increased there seems to be no reason why it should not be employed more extensively.

USES

Ocher is used primarily as a pigment and as a mineral filler, although there are many minor uses. It is used both as a filler and coloring material in the manufacture of linoleum, oilcloth and wall paper. Ocher is also used in the manufacture of protective paints for the exterior of buildings, bridges, roofs, railway cars and the like. It has some application as a filler in the manufacture of certain kinds of yellow, brown and red paper; in the manufacture of rubber products; and as a pigment for coloring mortars, plasters and cement. Yellow ocher has been employed to some extent as a filler for fertilizers because of its close resemblance to cotton-seed meal, however, the author does not recommend this use for the Alabama product.

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[1] Santmyers, R. M., *Ocher and Ochery Earths,* Circular 6132, U. S. Bureau of Mines, 1929.

Ocher mixed with the required proportion of oxide of manganese has been used to impart colors to earthenware. Special grades of some of the better ochers are used in the manufacture of high grade mixed paints, and even in making artist's colors.

DOMESTIC PRODUCTION, IMPORTS, AND PRICE

In 1927 the production of ocher in the United States was placed by unofficial estimates at 22,000 tons, of which Georgia was responsible for 15,000 tons, Pennsylvania 5,000 tons, and all others 2,000 tons.[1]

The production of all iron oxide pigments and fillers, both natural and artificial, including ocher, sienna and umber, for the same year, amounted to 54,180 tons, valued at $3,357,895.

The imports of ocher and sienna into the United States in recent years have shown a gradual increase. The tonnage from France, which country supplies the greater part of the ocher imported into the United States, has shown practically no increase, although the value of the product has more than doubled in the last five years. Italy is the largest producer of high grade sienna and supplies most of this mineral imported into the United States.

In 1927 the ocher and sienna imported amounted to 10,436 tons, valued at $448,494. Of this amount, France supplied 8,329 tons, valued at $323,600.

The current market price of ocher, f.o.b. Georgia mines, as listed in the Engineering and Mining Journal, is given below.[2]

In sacks, $19 to $20 per ton; in barrels, $21 to $22 per ton. Washed and water floated, $18 per ton. Second grade, 99 per cent through a 225-mesh screen, $18 per ton.

DESCRIPTION OF INDIVIDUAL DEPOSITS

CLARKE COUNTY

Jackson.—A bed of yellow ocher outcrops just east of the highway about one and one-half miles north of Jackson. This exposure is near the summit of a plateau and about sixty feet above the adjacent stream courses. The bed is made up of two benches, each about two and one-half feet thick. The upper bench carries good quality ocher, while the lower bench is of a lower grade and contains a considerable amount of gray clay. The ocher of the lower bench gradually passes into gray and bluish clays below.

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[1] Santmyers, R. M., *Ocher and Ochery Earths,* Circular 6132, U. S. Bureau of Mines, 1929, p. 14.

[2] *Market and Financial News,* Engineering and Mining Journal, Volume 129, No. 6, 1930, p. 328.

The overburden, consisting of red sandy clay packed with gravel, has a maximum thickness of twelve feet. The ocher outcrops at several places nearby, and the bed seems to be fairly uniform and consistent.

Both benches are being worked at the present time, although the grade of the final product would be considerably improved if only the upper bench were mined. The ocher is dug from the open cut with picks and shovels and placed in large covered wooden racks, where it is dried by heat from the sun. The dried material is then hauled to the mill about one-third mile distant, where it is prepared for the market. At the mill it is first crushed between steel rolls and then conveyed to pulverizers, where it is reduced to the desired fineness. The pulverizd ocher is passed through an air-current classifier where the coarser and heavier particles are separated, and the purified product is collected in bags for shipping. The ocher is not washed by the producers.

Walker Springs.—A bed of ocher about eight feet thick is exposed near the summit of a flat-topped hill about three miles southeast of Walker Springs. The material is of a dark, yellow color except for the lower two feet, which grades into yellow clay, and finally into mottled gray and yellow clay. A ledge of ferruginous sandstone immediately overlies the ocher, and above this ledge from three to fifteen feet of sand and clay complete the overburden. Outcrops appear at several places around the hill.

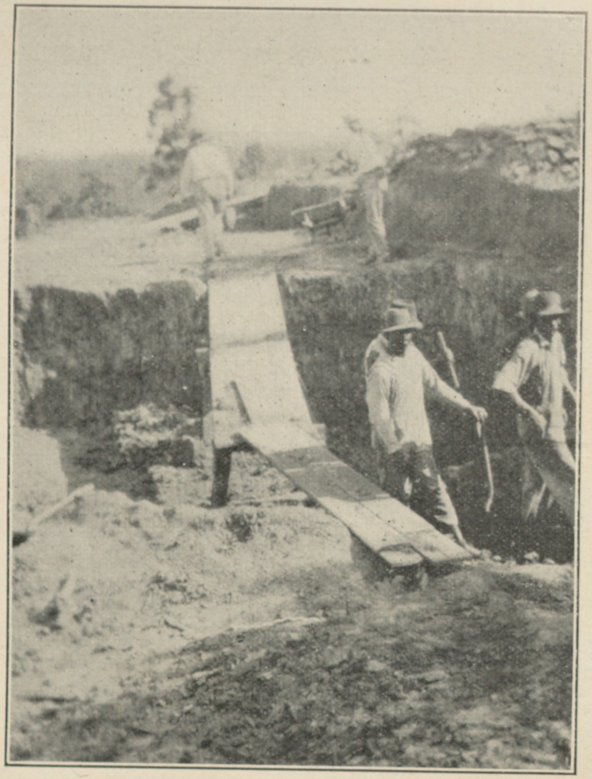
Some ocher has been mined from this deposit and hauled to the mill at Jackson, where it was prepared for market. The railroad at its nearest point is about three miles distant.

MONROE COUNTY

Perdue Hill.—Ocher outcrops about three miles east of Perdue Hill in a gully just north of the principal highway to Monroeville. This bed is four and one-half feet thick and is of a bright, yellow color. The underlying material is blue clay. Immediately above the ocher is a ledge of ferruginous conglomerate, four inches thick, which is in turn overlain by sand and gravel ranging up to seventy-five feet in thickness.

A number of exposures, evidently of the same bed, have been reported in this general locality so that the bed seems to be fairly uniform over a considerable area.

PLATE 2



A.—Deposit of yellow ocher about three miles southeast of Walker Springs, Clarke County.

B.—Deposit of red ocher in abandoned brown iron ore workings at Shelby, Shelby County.

The above described exposure is about five miles from the Alabama River and about ten miles from the railroad at Monroeville.

Jones Mill.—A bed of yellow ocher outcrops in the banks of a small stream about five miles southwest of Jones Mill in the following stratigraphic section:

Character of Materials	*Thickness in Feet*
White and yellow sand	20
Gray clay	10
Ferruginous sandstone	½
Yellow ocher	2

BARBOUR COUNTY

Baker Hill.—A bed of yellow ocher is exposed near the water level in a deep stream-cut ravine about one mile southeast of Baker Hill. The overburden at the outcrop is fifteen feet thick, but back from the stream course it reaches a maximum of about seventy-five feet. The transportation facilities are poor since the deposit is about nine miles from the Central of Georgia Railroad and about ten miles from the Chattahoochee River. The stratigraphic section is given below:

Character of Materials	*Thickness in Feet*
Clay to top of bluff	15
Ferruginous sandstone	2
Yellow ocher	5
Gray clay	10

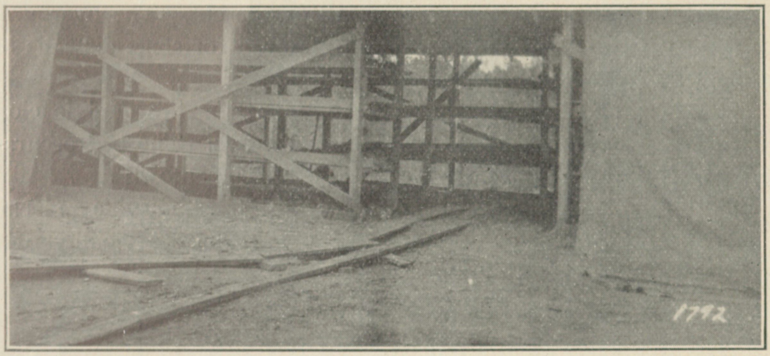
AUTAUGA COUNTY

Vine Hill.—A bed of yellow ocher four feet thick is exposed in the bed and banks of a small stream about one and one-half miles east of Vine Hill. This material contains a considerable proportion of quartz sand and many small flakes of mica. A ledge of ferruginous sandstone six inches thick lies on top of the bed and above this ledge from one to fifteen feet of vari-colored sands complete the overburden. A small amount of ocher has been mined from this vicinity, although not from this deposit.

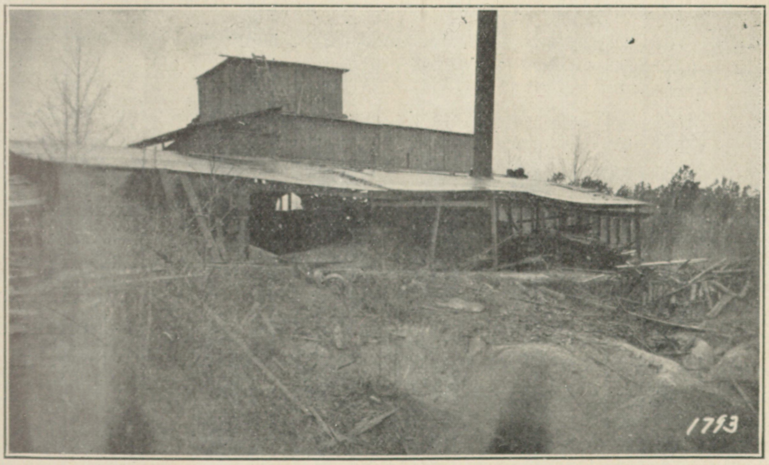
The Southern Railroad passes through Vine Hill, which is about two miles distant by dirt road.

Prattville.—There is a rather unique deposit of red ocher just east of the Birmingham to Montgomery highway about six miles north of Prattville. The deposit occurs as a practically vertical vein from ten inches to two feet wide, however, the average is nearer the lower limit. The enclosing material is a slightly consolidated ferruginous sandstone, and the contact between it and the ocher is sharp. The ocher has been traced for a distance of about 600 feet east of the highway.

PLATE 3



A.—Shed and racks for air-drying ocher at Jackson, Clarke County.



B.—Mill for preparing ocher at Jackson, Clarke County.

SHELBY COUNTY

Shelby.—A deposit of red ocher occurs in the abandoned brown iron ore workings about one-half mile northwest of the town of Shelby. The ocher forms a hill about fifty feet high, which rises from the floor of the cut, and near the southwest limit of the workings it appears as a bed about fifteen feet thick near the top of the wall of the cut. The overburden, which consists of sand and clay, has been removed for some distance back from the main workings for its limonite content.

The ocher contains many small pebbles of hematite, and is closely associated with the limonite bearing sands and clays. The bed occurs on but not in the cherty Ordovician limestone of Beekmantown age.

An old iron ore railroad, which connects with the Louisville and Nashville in the town of Shelby, extends into the immediate vicinity of the ocher deposits, thus furnishing excellent transportation facilities.

COLBERT COUNTY

Allsboro.—Ocher outcrops in the bed and bank of a small stream in Section 6, T. 4S, R. 14 W., about four miles northwest of Allsboro. This material is of a light yellow color and contains many thin streaks of white clay. A ledge of ferruginous conglomerate three inches thick immediately overlies the ocher, and this ledge is in turn overlain by about twelve feet of sand and gravel to the top of the bluff. The overburden increases away from the stream to about 35 feet.

Mr. J. W. Adams of Sheffield, who has prospected the area, reports that the ocher is pockety, but that it has a maximum thickness of eight feet.

RESUTS OF TESTS

SOURCES OF SAMPLES

Samples from all the known deposits could not be collected and tested, so representative samples were taken from the more important deposits. These samples have a wide variation in character as will be noted from the following tables, and it is believed that they represent all the types of ocher found in the state.

Sources of Ochers Tested

Sample No.	*Location of Deposits*
1.	About three miles southeast of Walker Springs, Clarke County.
2.	About one-half mile southeast of Baker Hill, Barbour County.
3.	Just east of principal highway one and one-half miles north of Jackson, Clarke County.

4. Prepared sample collected from the mill at Jackson, Clarke County, June 21, 1928.
5. About three miles east of Perdue Hill, just north of the main highway to Monroeville, Monroe County.
6. Prepared sample of the material formerly marketed from Coosada, Elmore County.
7. Four miles northwest of Allsboro, Colbert County.
8. In brown iron ore workings at Central Giles, Tuscaloosa County.
9. In abandoned brown iron ore workings at Shelby, Shelby County.
10. Just east of Birmingham to Montgomery highway, six miles north of Prattville, Autauga County.

WASHING

The crude ocher was thoroughly air dried and crushed to pass a 35-mesh screen. The reason for the coarse initial crushing was to avoid undue grinding of the coarser-grained impurities. Small laboratory samples of the crude materials were washed by a process of elutriation in order to remove the heavier and coarser particles. It is believed that these products were better than would ordinarily be obtained on a commercial scale. The washed ocher in suspension was allowed to settle out and the clear water above was syphoned off. The water remaining in the thickened pulp was evaporated over a steam bath and the solid cake was thoroughly dried at 105 degrees Centigrade, when it was ground in a small disk pulverizer to pass a 200-mesh screen.

All the tests described below were made on this washed and dried product with the single exception of the percentage of coarse-grained residue which was made on the crude material.

CHEMICAL ANALYSES

The chemical analyses were all made on the washed ochers, and the percentages of combined water, ferric oxide, silica, alumina and lime were determined. These are the principal constituents that have an appreciable influence upon the value of the ochers, although others are present in very small amounts. The methods of analysis employed were adapted from those ordinarily followed in analyzing clays.

Certain specifications require that these constituents be present within certain definite limits; thus the chemical analysis may serve to eliminate certain wholly undesirable ochers and to classify the better ones according to probable uses.

From the chemical analyses the principal mineralogical constituents of the ochers were calculated. The microscope was used to advantage along with the chemical analysis in determining the composite minerals.

The following tables give the chemical analyses of the ochers tested and the theoretical mineralogical constituents as calculated from these analyses:

Chemical Analyses

Sample No.	*Combined Water*	Fe_2O_3	SiO_2	Al_2O_3	*CaO*
1	13.6%	40.0%	27.2%	19.0%	0.54%
2	13.4	16.7	39.5	30.4	0.49
3	7.4	18.3	59.4	13.0	0.31
4	5.9	10.6	68.4	14.4	0.41
5	5.3	9.3	70.2	14.0	0.47
6	7.9	6.5	61.8	21.3	0.47
7	9.0	6.8	55.9	26.7	0.52
8	8.2	4.4	58.8	26.1	0.55
9	11.8	15.5	43.4	26.9	0.46
10	15.1	13.1	34.4	36.8	0.39

Mineralogical Composition as Calculated From the Chemical Analyses

Sample Number	*Limonite*	*Hematite*	*Kaolin*	*Silica Sand*	*Calcium Carbonate*	*Bauxite*
1	45.8%	....	48.1%	5.0%	0.96%	....
2	19.5	....	77.0	4.0	0.88	....
3	21.4	....	32.9	4.2	0.55	....
4	12.4	....	36.4	51.6	0.73	....
5	10.9	....	35.4	53.8	0.84	....
6	7.6	....	53.9	36.9	0.84	....
7	9.2	....	67.6	24.7	0.93	....
8	9.6	....	66.1	28.3	0.98	....
9	....	15.5%	68.1	12.0	0.82	....
10	....	13.1	73.8	....	0.70	10.3%

COARSE-GRAINED RESIDUE

A one-hundred gram sample of the dried 35-mesh ocher was transferred to a 200-mesh screen and a gentle stream of water was played upon the screen until the finer-grained materials had been washed through. The particles remaining on the screen were dried at 105 degrees Centigrade, weighed and reported as residue on 200-mesh. The residue was examined under the microscope in order to determine its mineralogical character. Chemical analyses were made when desirable.

Amount and Mineralogical Character of Coarse-Grained Residue

Sample Number	*Residue on 200-mesh*	*Mineralogical Composition of Residue*
1	5.5%	Largely colorless grains of quartz with some mica flakes and black fragments of manganese oxide.
2	3.0	Colorless quartz grains with some small flakes of mica.
3	0.5	Colorless quartz grains with a few small flakes of mica.

4	8.6	Colorless quartz grains with a small amount of mica flakes.
5	12.3	Grains of colorless quartz with a small amount of mica flakes.
6	2.3	Grains of colorless quartz with a considerable proportion of mica.
7	0.5	Colorless grains of quartz.
8	0.5	Colorless grains of quartz.
9	29.8	Colorless grains of quartz with a considerable amount of red hematite and a small proportion of mica.
10	33.3	Largely colorless grains of quartz with some ferruginous sandstone and mica flakes.

SPECIFIC GRAVITY

The true specific gravity was determined by the ordinary pyknometer method, using five-gram samples of the pulverized and dried ochers.

OIL ABSORPTION

Several methods of determining the oil absorption of pigments are in use, but the method employed in this work was that developed by Gardner and Coleman.[1] The pulverized ocher was dried at 105 degrees Centigrade and cooled in a closed bottle to room temperature. Before each test the bottle was shaken so as to break up any lumps in the ocher. Twenty grams of this material was weighed out and transferred to a round-bottomed jelly glass. Filtered linseed oil was added drop by drop from a burette, and the ocher was lightly stirred with a stiff spatula until each particle of the mass was wet. This condition was reached just before the oil began to show on the surface of the pigment at which time it began to smear the sides of the glass. The ochers agglomerated upon the addition of the oil; some into one large lump and others into many smaller lumps. The end point represents that point at which the surface of each particle of the mass is thoroughly wet by the linseed oil and the ocher becomes thoroughly saturated.

The following table gives the true specific gravity and oil absorption of the ochers tested:

Specific Gravity and Oil Absorption

Sample Number	*True Specific Gravity*	*Linseed Oil Required to Saturate* 100 *Grams of Ocher*
1	3.06	45.0 c.c
2	2.72	46.0
3	2.91	36.5
4	2.76	34.0

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[1] Gardner, H. A., and Coleman, R. E., *Oil Absorption of Pigments,* Circular No. 85, American Paint and Varnish Manufacturers Association, 1920.

5	2.70	31.5
6	2.75	37.0
7	2.80	38.5
8	2.55	38.0
9	2.81	43.5
10	2.73	55.0

COLOR

Samples Number 1 to 8, inclusive, were of the yellow variety of ocher, while Numbers 9 and 10 were of the red variety. The samples of each variety were numbered according to the intensity of their shade, as for example, Number 1 was of a dark yellow color and each succeeding sample was lighter than the preceding one until the lightest of the series, Number 8, was reached. Among the reds, Number 9 was darker than Number 10. Number 1 was a brownish yellow; Numbers 2, 3, 4 and 5 were golden yellow; Numbers 6 and 7 were light yellow; and Number 8 was a pale yellow. Number 9 was of a burnt sienna color, while Number 10 was reddish orange.

CALCINING

Since the amount of water combined with the ferric oxide of the yellow ochers is known to have an important influence upon their color, a series of tests were made to determine the effect upon the samples collected of heating them at different temperatures for different periods of time. The method of procedure is given below:

A five-gram sample of the pulverized ocher, dried at 105 degrees Centigrade, was transferred to a weighed porcelain crucible and heated in an oven at 200 degrees Centigrade for one hour, when it was cooled in a desiccator and reweighed. This weight, together with the time of heating and the color of the product, were recorded. The sample was further heated at the same temperature for additional periods of time of one hour, two hours, three hours and six hours, making a total of fifteen hours. After each period the weight and color of the sample were recorded; the loss in weight was taken as combined water. The temperature was held constant and the test was considered complete when both the weight and color of the sample showed no appreciable change for two successive periods of heating.

The procedure was repeated at temperatures of 300, 400, 600, 800, 1000 and 1100 degrees Centigrade, although as the temperature was increased the period of time between weighings and the total time of heating were steadily reduced as was found desirable.

Even at 200 degrees Centigrade, the change in color of most of the samples tested was decided, and there was a gradual increase in depth of color of the calcined products at temperatures up to 600 degrees Centigrade. Above this temperature the colors of the calcined products again became lighter, as for example, for a given ocher the product obtained at 1000 degrees was of approximately the same shade as that produced at 300 degrees. At 300 degrees Centigrade the colors of all the ochers tested were completely changed, and the shades were almost as dark as those produced at 600 degrees.

At 300 degrees Centigrade the maximum change in color was brought about in from one to two hours; at 600 degrees from fifteen to thirty minutes; and at 1000 degrees from five to ten minutes.

The amount of the combined water driven off during the calcining operation varied with the different samples and with the temperature employed, but at 600 degrees Centigrade the ochers tested lost from 75 to 90 per cent of their combined water.

The following table gives the color of the calcined product obtained at 600 degrees Centigrade from each of the samples of ocher tested:

Colors of Calcined Products

Sample No.	*Color*
1	Dark reddish brown
2	Purplish red.
3	Dark reddish orange.
4	Brownish orange.
5	Dark orange.
6	Brownish orange.
7	Orange.
8	Light pinkish orange.

SUMMARY

The yellow ochers represented by the first five samples have bright colors, and can probably be used as mineral pigments, although the ferric oxide content of the last two does not come up to the United States government specifications, and Number 5 has a considerable proportion of coarse-grained impurities. Thus these ochers have possibilities both as pigments and fillers. The next three samples, Numbers 6, 7 and 8, are not suited for pigments because of their low content of ferric oxide and resulting weak colors, but they seem to be satisfactory for fillers in which the color is not of prime importance.

The red ochers, Numbers 9 and 10, contain a large proportion of coarse-grained impurities which must be removed by washing, thus adding to the cost of the final product. In spite of this disadvantage, Number 9 seems to have commercial possibilities as a pigment and filler, but Number 10, because of its weak color, its high oil absorption property and its high alumina content, does not appear to be of commercial importance.

With the exception of Number 10, the oil absorption is not excessive for any of the samples tested, although Numbers 1, 2 and 9 are rather high. The content of calcium carbonate, less than one per cent in each of the samples tested, is well within the limits set by the U. S. government specifications. Again, with the exception of Number 10, all the ochers tested have a siliceous base, which is another of the requirements of the government specifications.

Upon calcining, the yellow ochers tested assumed red, brown and orange colors. Sample Number 2 gave a purplish red product, which is very desirable. The red ochers, Numbers 9 and 10, were not appreciably changed by calcining, although the products obtained were of somewhat lighter shades than the original materials. The color of one of the samples, Number 7, was not much changed at 200 degrees Centigrade, even after heating for fifteen hours, and all the samples assumed gray, greenish gray or black colors when heated at approximately 1100 degrees Centigrade. However, satisfactory products were obtained at both 300 and 1000 degrees Centigrade. Since the brightest and darkest colors were produced at 600 degrees Centigrade, and since the conversion was brought about in a comparatively short time, this temperature appears to be the most desirable for the calcining operation.

Probable Uses.—The following table gives the commercial uses for which the ochers tested seem best suited:

Probable Uses of Ochers Tested

Sample No.	*Probable Uses*
1	Paint, linoleum and oilcloth.
2	Paint, linoleum and oilcloth.
3	Paint, linoleum and oilcloth.
4	Paint, linoleum and oilcloth.
5	Paint. linoleum and oilcloth.
6	Linoleum and oilcloth.
7	Linoleum and oilcloth.
8	Linoleum and oilcloth.
9	Paint, linoleum and oilcloth.
10	Doubtful.

Economic Factors.—In addition to satisfying the preceding specifications, a deposit of ocher to be of economic importance must have the following characteristics: (1) The deposit must be so situated that the material can be easily and cheaply mined; (2) the available reserve must be large enough to repay the investment required to put the deposit on a paying basis. This investment would represent the cost of opening up the mine, the cost of machinery and equipment, and the cost of building roads; (3) the deposit must be situated closely enough to railroads or navigable rivers and to important markets that the product can be economically marketed; (4) the ocher must be uniform in color and physical properties; (5) the material must be reasonably free from impurities so that it can preferably be used without purification, but if washing is necessary there must not be too great a loss during the operation.

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